implications for the ability to turn freely and quickly to either side are of immediate interest. Do they bias turning? If so, how is the bias counteracted in the natural environment? If not, how is the dissociation achieved?

We may divide asymmetries into those that are species-specific (like human handedness) and those that are consistent within individuals but equiprobably right or left across individuals (like paw preference of many animals). Among the systematic asymmetries, we distinguish the neuromotor, which cause turning bias, the cognitive, which do so only indirectly and minimally, and structural ones that are of trivial or uncertain functional significance. Of each we may ask: Does it bestow adaptive advantage? Does it reflect some superordinate organizational principle, of which it is merely derivative? Or is it due to relaxation of the need for bisymmetry, which perhaps only occurs when specifically programmed?

Of the papers presented in *Lateralization in the Nervous System*, 23 deal with asymmetries from a theoretical, empirical, or methodological standpoint and three with hemisphere interaction. Of those presented in *Evolution and Lateralization of the Brain* 30 deal with issues of asymmetry and nine with other matters pertinent to the evolution of the nervous system. I will consider the papers with respect to questions raised above.

Of the asymmetries discussed in the books the ones most obviously relevant to movement are the rightward turning biases of rats (Glick *et al.*, both volumes), of human infants (Turkewitz, both volumes), and of human adults with lateral cerebral lesions (Heilman and Watson, *Lateralization*). Lateral gaze deviations that accompany the adoption of a particular mental set (Gur and Gur, Anderson, *Lateralization*) are minor reorientations secondary to higher mental activity, and perceptual asymmetries in normal adults (Berlin [auditory], Springer [visual], *Lateralization*) may represent corresponding shifts in attention that are premotor or submotor in nature. Indeed, the event-related electroencephalographic changes studied by Donchin *et al.* and Thatcher (*Lateralization*) do not necessarily represent the cognitive activity in process but could represent lateralized orienting responses in relation to the side of the brain being used. Indeed, this would make it understandable why infants who are quite unable to process speech or music show lateralized EEG response to speech and musical stimuli (Gardner and Walter, *Lateralization*). Stamm *et al.*'s analysis (*Lateralization*) of the functional asymmetry in the monkey's frontal cortex also implicates manual and spatial orientation preferences. Finally, a lively debate on the origins of hand preference (Collins, both volumes; Warren, Morgan, *Lateralization*; Levy, Dewson, Nebes, *Evolution and Lateralization*) bears on the issue of whether this is a component of a species-specific rightward turning bias. If so, this would best be considered as part of a consummatory synergism, initiating manipulation subsequent to effective approach to the object. At this stage, differentiation of manual skills (Wolff, *Evolution and Lateralization*) is consistent with adaptive needs.

It appears that neuromotor asymmetries either do not have implications for turning or, if they do, can be stabilized on the basis of perceptual orientation in normal environments. But are they adaptive in themselves? Perhaps a lateral bias is a point of reference for right-left orientation (Glick *et al.*, *Evolution and Lateralization*).

The most massive lateralization is in humans: the double functional dissociation between left verbal-analytic and right spatial-wholistic processing at the hemispheric—and even the thalamic (Riklan and Cooper, *Lateralization*; Ojemann, *Evolution and Lateralization*)—level.

This asymmetry generates only minimal turning biases. It became possible because the mental processes subserved deal not with the concrete physical environment but with central representations thereof, which, as Levy (both volumes) points out, can be found in either hemisphere as well as across the two. Whether the mental representations that form in the two hemispheres differ qualitatively and how such differences might relate to the presumed unity of consciousness is debated by Eccles, Galin, Gazzaniga, Puccetti, and Whitaker and Ojemann in *Evolution and Lateralization*. The functional advantage, if any, of lateralization is the subject of intriguing speculation by Levy (*Evolution and Lateralization*). But the test case, the left-hander whose cerebral organization is anomalous (mirror image or unlateralized) by reasons of inheritance or early brain damage (Rasmussen and Milner, *Evolution and Lateralization*), proves a disappointment, showing either no deleterious consequences of the anomaly or confusing outcomes (Kocel, Stamm, *Evolution and Lateralization*). Perhaps the variability of lateralization is an example of diversity in human brain organization (Gazzaniga, *Evolution and Lateralization*) with few if any functional implications. If so, it still might have had such implications at the stage in hominoid evolution in which the genetic programs that control it were selected (Levy, *Evolution and Lateralization*).

In contrast to the vitally important lateralized functions in humans are some anatomical asymmetries of brain that, though minor and rather inconstant, appear to be species-specific (Rubens, *Lateralization*; Wada, Witelson, *Evolution and Lateralization*). Their functional significance remains to be determined.

Possible model systems are considered, ranging from heterochely in crustaceans, considered from the viewpoint of asymmetrical neural control (Chapple, both volumes), and positional orientation (Schöne, *Evolution and Lateralization*), through the lateralized control of song in songbirds (Nottebohm, *Lateralization*). In addition, the volumes contain accounts of apparently successful (Stamm *et al.*, *Lateralization*), promising (Dewson, *Lateralization*), or unsuccessful (Hamilton, both volumes) attempts to train monkeys in potentially lateralized skills. Attempts with cats are also reported (Webster, Nelson *et al.*, *Lateralization*).

On reviewing the wealth of information and opinion represented in these two books, one cannot help being tantalized by the fact that, although clues abound, not a single major issue with respect to lateralization has been definitively resolved. No wonder so many of us find this field of scientific endeavor irresistible.

MARCEL KINSBOURNE
Neuropsychology Research Unit,
Hospital for Sick Children,
Toronto, Ontario M5G 1X8, Canada

The Oculomotor System

Control of Gaze by Brain Stem Neurons. Proceedings of a symposium, Paris, July 1977. R. BAKER and A. BERTHOZ, Eds. Elsevier/North-Holland, New York, 1977. xvi, 514 pp., illus. $59.95. Developments in Neuroscience, vol. 1.

Movements of the Eyes. R. H. S. CARPENTER. Pion, London, 1977 (U.S. distributor, Academic Press, New York). xvi, 420 pp., illus. $27.

The Brain and Regulation of Eye Movement. A. R. SHAKHNOVICH. Translated from the Russian edition (Moscow, 1974) by Basil Haigh. Plenum, New York, 1977. x, 190 pp., illus. $25.

If there is any central neural apparatus that should be ready to yield to modern neurobiological probing, it is the mammalian oculomotor system. After all, the behavioral laws governing eye movements were discovered during the middle of the last century; clinical neuro-ophthalmological syndromes have been delineated for even longer; psychophysiologists and cyberneticists have been cleverly manipulating stimuli ever since Dodge classified human eye movements in 1903; neurophysiologists elucidated the operation of the nerve cell and the synapse in the 1950's and 1960's; neuroanatomists are now making giant strides; and analysis of the visual sensory system has proceeded so well that it is common to encompass the behavior of single cells and the whole animal in a unitary description. So it is now clearly the turn of the visual motor apparatus, which, as Hering phrased it, "has to fit the sensory apparatus as the shell does an egg."

The three books here reviewed are all timely, and each in a different way makes an interesting contribution. Baker and Berthoz convened a satellite symposium of the 1977 International Congress of Physiology in Paris last July. The proceedings of the symposium, appearing within a remarkably short time, contain over 50 papers by more than a hundred participants. It was quite an achievement to have present in one place at one time a major proportion of the significant contributors in the field. As a consequence we have here what amounts to a progress report on the state of research on the oculomotor system.

Searching the book for a complete delineation of the brainstem apparatus for gaze control reveals that there is none as yet, though some partial characterizations are emerging. In particular, the signal sequence required for the generation of saccades and of vestibulo-ocular responses would seem close to being adequately characterized. But in the alert mammal, which is of course the ultimate preparation in this research, the colliculi, cerebellum, and cortex are all significant in even the most routine operation of motor sequences. In the oculomotor system one is dealing with a distributed network strongly modulated by, and interacting with, other pathways. So it is perhaps a little too optimistic to expect the kind of rigorous connectivity schema that has been constructed for, to cite an example, the retina.

Carpenter's book is almost exactly complementary to the Baker and Berthoz symposium volume. Here is a young English physiologist, obviously intelligent and analytical, displaying an attractively wide cultural vista that is unfortunately not open to most laboratory researchers struggling with the daily routines of single-cell recording in alert mammals. The result is an excellent overview of the field, including its behavioral aspects. The book deserves to be read widely since it provides the setting within which the popular single-cell neurophysiology is really meant to be understood. Because of the varying degrees of facility with which neurological researchers describe their findings, a synthesizer can be at a disadvantage when some consequential facets of a syndrome are incompletely reported. Carpenter thus occasionally runs into the difficulties inherent in the attempted encapsulation of widely diversified research findings. In sketching the contemporary scene of ocular motility research in historical perspective, Carpenter merits the gratitude of all workers in the field, whose bearings will be more secure as a result of his survey.

At first glance one may wonder why the trouble was taken to translate Shakhnovich's book from the Russian, but detailed perusal makes it apparent that there are several matters discussed in the book for which there is no overlapping treatment in English. It is of interest to note that, if Shakhnovich is representative, Russian workers have much the same view of the importance of current trends as we have. Shakhnovich himself seems driven by a wide-ranging curiosity to investigate topics as diverse as single units in the rabbit cortex, the trajectory of saccades, the accommodation-convergence synkinesis, and cerebral blood flow in various diseases. By current American standards he would be faulted for attempting too much and hence for failing to make his results fully convincing. The book incidentally contains a lesson about scientific attitudes common to East and West. One might have thought that the same scientific enterprise that sent space probes to look at the surface of Venus and Mars would have also prompted a look at the ocular tremor in humans as a possible diagnostic and prognostic tool. In the West, this approach is almost totally ignored. When Shakhnovich attempts it in Moscow, he seems to have to count cycles of ocular tremor by hand, four decades after Kolmogoroff (in the same city) developed elegant methods of harmonic analysis.

All three books can be recommended: Carpenter's monograph for providing a much-needed framework and overview, Baker and Berthoz's symposium volume for making available an up-to-date progress report from a large segment of the research community, and Shakhnovich's book for showing us the directions in which one person's interest can lead him.

GERALD WESTHEIMER
Department of Physiology-Anatomy, University of California, Berkeley 94720

Bases of Motivation and Learning

Drives and Reinforcements. Behavioral Studies of Hypothalamic Functions. JAMES OLDS. Raven, New York, 1977. viii, 140 pp., illus. Paper, $8.75.

W. R. Hess earned the Nobel prize for discovering and studying the remarkable fact that electrical stimulation of localized regions deep within the brain can drive an animal to perform behavior that seems natural, for example, to eat as if hungry or to drink as if thirsty. Would James Olds, had he lived longer, have received the prize for discovering and studying electrical self-stimulation?

Olds was a prospector in physiological psychology. This book summarizes his search for the neural basis of motivation and learning. Starting out at McGill University to explore the reticular formation, he stumbled onto electrical self-stimulation of the forebrain. Anyone less astute or less energetic might have thrown out the strange rat that refused to run down the alley during brain stimulation. The rat kept coming back to the place where stimulation was turned on. Olds knew he had discovered a gold mine of information. The excitement spread when he trained a rat to press a switch 3000 times an hour to stimulate its own brain. Olds performed the basic experiments in every area of self-stimulation research. He and his colleagues mapped brain reward sites, studied the effects of major drugs, related self-stimulation to natural rewards, and started electrophysiological probing of the cellular basis of reward. Today self-stimulation is the major technique for studying the neural basis of the psychopathology of drive and reinforcement.

This simple and insightful book does three things. It demonstrates Olds's question-and-answer approach to brain research, it integrates the basic findings in neuroanatomy, neurochemistry, and electrophysiology that are related to